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FALCONS REJECT UNFAMILIAR PREY¹

by

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The factors controlling predation are complex and currently not well understood. Variables are involved that pertain individually to the predator and to the prey and their interaction contribute to the probability of an attack. Much experimental work investigating predation has centered about factors dealing mainly with the prey item. For example, prey movement is known to be important in controlling the predatory activity of a variety of raptors (e.g., Metzgar 1967, Sparrowe 1972, Kaufman 1974b, Snyder 1975). Oddity has been implicated (Mueller 1974, 1975), as has a factor called novelty (Coppinger 1969, 1970). Color (Cushing 1939, Kaufman 1974a), conspicuousness in terms of contrast with substrate (Mueller 1968, Kaufman 1972, 1973), and searching image (Tinbergen 1960, Mueller, 1971, 1974) are other variables often manipulated. It is infrequent, however, that the interaction of variables is studied extensively within a single experiment. However, Ruggiero (1975) and Snyder (1975) have looked at some such interactions, and the present paper summarizes part of an extensive experiment (Ruggiero, Cheney and Knowlton, 1979), emphasizing the importance of prey characteristic (i.e., color, movement, etc.) interaction in determining probability of prey selection by American Kestrels (*Falco sparverius*).

Methods

Using outdoor aviaries (6×3×3 m with solid gridded sides, rodent-proof bases, and dark brown peat-moss substrates) and four wild-caught (experience unknown) adult kestrels, we attempted to assess the influence of some interacting prey (mouse) characteristics on predatory selection. The independent variables of this study (see table 1) included prey movement (aberrant movement induced by drug injection, normal movement, or no movement), pelage color (white or black), and morphology (familiar or artificially made unfamiliar). Table 1 describes in detail each treatment of each variable. The familiarity variable was represented by prey items that were made morphologically discontinuous with the bird's probable prior experience (i.e., they were created so as to be novel). It is difficult to alter the appearance of a mouse to that which is clearly novel without also changing either its size or its carriage. Pilot investigation, however, determined that "extending" the tail with yarn the same color as the mouse and adding a similarly colored cotton ball on the mouse's back did alter morphology so as to in fact create sufficient novelty. We realize, however, that any stimulus is novel or unfamiliar only at first exposure. After that the object is simply more or less familiar. Treatments were affected, and prey items defined as per table 1, with each prey item displaying one treatment per variable.

¹We thank Drs. D. Balph and F. Knowlton for assistance with this research and Dr. D. Sisson for statistical consultation.

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All possible treatment combinations of the 12 types of mice (*Mus musculus*) were presented by the experimenter simultaneously in pairs, to the four kestrels (two males and two females) one trial per day. Sequences of 16 trials for birds 5 and 6 and 17 for birds 3 and 4 provided 66 total experimental trials. The mice were released (or placed, when they were dead) 3.5 m in front of the kestrels' 1.5-m-high perch. The experimenter then left the enclosure and, with an observer, recorded time required by the Kestrel to choose (kill), which item of the two was selected, prey position when struck, and prey preattack movement. Mouse movement was scored as not active, moderately active, active, and very active based on the number of grids crossed prior to selection. Some mice were injected with pentobarbital (see table 1) so as to induce abnormal movement. These treated mice moved in a qualitatively different manner from noninjected mice in that they tended to stagger and sway, they groomed the injection site, and they appeared overtly awkward. There were no significant differences in quantity of movement between aberrant or normal mice (movement variable) or between black and white as determined by number of grid lines crossed.

Table 1. Independent Variables and Treatments for Prey Characteristics

Prey variables	Treatment	Characteristic
Movement	No movement	Dead mouse
	Aberrant movement	Mouse injected with .0lcc/ 6g body wt. 25% sodium pentobarbital (Nembutal)
	Normal movement	Untreated
Pelage color	White	White-pelaged lab mouse
	Black	Black-pelaged lab mouse
Morphology	Familiar morph	Normal mouse without treatment or modification
	Unfamiliar morph (smaller mice were used in this category to equate overall apparent size)	A mouse with a 7.5 cm piece of black or white yarn tied to its tail and a 1.2-cm black or white cotton ball affixed to its back.

The 66 total experimental trials defined a balanced $2 \times 2 \times 3$ factorial design (Cochran and Cox 1957). The data presented here represent the pooled selection preferences of all four kestrels. These preferences were found to be a consistent (predictable) as opposed

to a random, scheme (the coefficient of consistence measure $\zeta = 0.64$; $X^2 = 15.00$; Kendall 1948). There was no significant preference for presentation side, location, or proximity. Birds would take mice wherever they were in the arena.

There was a significant interaction ($p = 0.01$; $X^2 = 15.04$) between movement and morphology, indicating that these variables did not act independently. Selection was very low for a moving, unfamiliar (because of either color or morphology) mouse and very high for a moving, familiar (either black or familiar) prey. Significant within-variable differences were also found for pelage color and morphology, but no other significant interactions occurred. Black pelage was selected significantly more than was white even on the dark substrate, and familiar morph prey were selected significantly more than unfamiliar ($p = 0.01$; $X^2 = 7.84$ for both within variable tests). This rejection of color and novel morphology supports Coppinger (1969, 1970) but is not in agreement with Mueller (1974, 1975). Birds were observed actually to retreat from a moving, white, unfamiliar morph. The interaction of all other prey characteristics with movement was very pronounced and tended to render unfamiliar prey even less desirable. Black pelage and familiar morphology were maximally selected when in combination with aberrant movement. All three of these variables could have occurred in combination in nature and therefore were not considered novel in this experiment. Movement of any kind enhanced selection for familiar prey and reduced selection for unfamiliar prey.

Discussion

The results of this study are considered further evidence that (1) prey movement is a most important factor in kestrel predation; (2) aberrant movement is a more effective attack stimulus than is normal movement; (3) prey items that are not discontinuous with a kestrel's experience are selected significantly more readily and often; (4) oddity, if it means novelty, reduces probability of attack; however, when the term *oddity* refers to "not matching" a simultaneously presented prey array, other factors are involved; (5) it is not the general case that raptors select prey solely on the basis of conspicuousness, i.e., such selection is not indicated when conspicuous prey are also unfamiliar in some aspect; (6) analysis for potential interaction is very important in this type of research; and (7) predator experimental and preexperimental experience is critical in assessing the influence of prey characteristics in selection experiments inasmuch as initially unfamiliar or novel stimuli become more familiar as a function of exposure.

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AN OCTAGONAL BAL-CHATRI TRAP FOR SMALL RAPTORS

by

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Several modifications of the bal-chatri trap for birds of prey have been used, most of which are described in the 1977 *North American Bird Banding Manual* (Vol. II: *Bird Banding Techniques*). Among these are the cylinder type (Berger and Mueller 1959, Mersereau 1975), the quonset or hemi-cylindrical type (Berger and Hamerstrom 1962, Berger and Mueller 1959, Mersereau 1975, Ward and Martin 1968), the box type (Clark 1967, Lohrer 1974, Mersereau 1975), and the cone and cube types (N. American Bird Banding Man. 1977). We have been using an octagon type of modified bal-chatri trap for several years, of a design quite different from any of the types listed above.

Our trap consists of an octagonal tunnel in which the bait-mice can run. We have found that mice tend to move more in this trap than in the quonset or box types, perhaps because there are no corners to huddle in. The tunnel also seems to produce more movement than the open spaces of the cylindrical trap. This increased movement of the mice makes the trap more effective in catching the birds' attention. We have had good success capturing American Kestrels (*Falco sparverius*) and Broad-winged Hawks (*Buteo platypterus*) with traps of this design.

The materials needed are (1) a 24-by-24 inch piece of hardware cloth (½-inch mesh is best, but is hard to find; ¼-inch mesh will work satisfactorily), (2) a 24-by-24-inch sheet of cardboard, (3) a can of spray paint (black or brown), (4) wire, and (5) 6- or 12-pound monofilament line, depending on the species to be trapped.

To construct a trap, draw the design, as shown in figure 1, on the sheet of cardboard. Cut out this cardboard pattern and trace it on the hardware cloth, using spray paint or a felt-tipped pen. Cut out the trap with tinsnips and make three 90° folds in each segment, along lines as shown in Figure 1 (B). Starting at the inside of each segment, the first fold is vertically upward, the next horizontally inward, and the third vertically downward to the flat base. This will form an octagonal tunnel. Wire the segments together and to the base, leaving one segment unwired to be used as a door. This segment can be temporarily secured with a twist-tie after the mice have been placed in the trap. Spray the entire trap with a dull finish paint and allow it to dry. Then place about three monofilament nooses on the top of each segment, and several along the sides. Nooses can also be placed in the central region of the octagon. Leave one segment with no nooses to serve as a place to hold the trap for Frisbee-style throwing. The completed trap is shown in figure 2, along with bait-mice and ensnared kestrel.

The base of the trap could be weighted if larger-than-anticipated hawks are likely to be baited—species such as the Red-tailed Hawk which could carry away a trap of this size. For our own method of cruising county roads and sailing the trap out a car window on sighting a kestrel, we have not found weighting to be necessary.

The octagonal bal-chatri might also be effective for shrikes (*Lanius* spp.) We have tried enlarging the pattern for trapping Red-tailed Hawk (*Buteo jamaicensis*), but have had more success with the quonset type of trap for these larger birds. We have not tried it on any of the other large hawks or any of the owls.

Acknowledgments

We are grateful to Ralph Meier, who originally conceived and designed the prototype of the octagonal bal-chatri.

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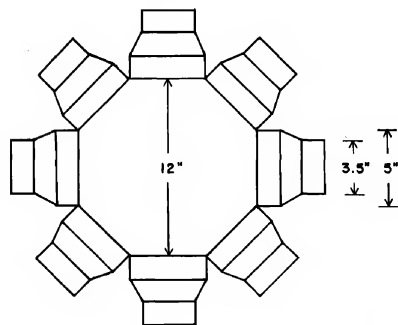


Fig. A

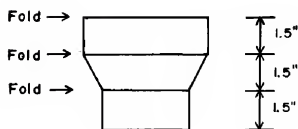


Fig. B

Figure 1.—Design for the octagonal bal-chatri trap:
(A) the complete pattern; (B) an enlarged pattern for
folding individual segments.

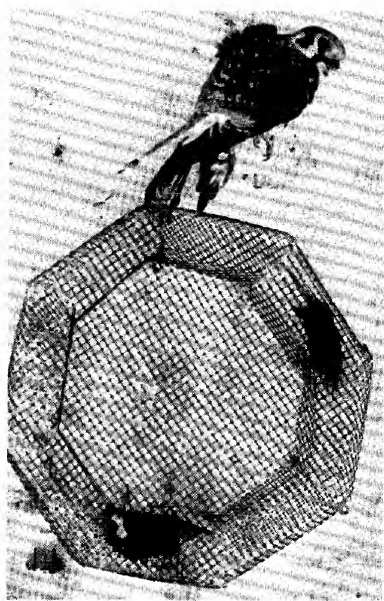


Figure 2.—The octagonal bal-chatri trap
with bait-mice and ensnared kestrel.

WINTER FOOD CACHING BY THE MERLIN (*FALCO COLUMBARIUS RICHARDSONII*)

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Food caching by the Merlin (*Falco columbarius richardsonii*) has recently been documented by Oliphant and Thompson (1976). However, winter caching and retrieving by this Merlin have not been documented. The following episodes took place within the city limits of Sheridan, Wyoming, during the winter and late fall periods of 1977.

On January 14, 1977, between 1200 and 1230 hours, Edward Pitcher and Stephen Martin observed a Merlin pursuing a small flock of waxwings (*Bombycilla spp.*) flying approximately 30 m high in a southerly direction. The flight ended in a miss, and the Merlin flew back toward Big Horn Avenue and landed on a utility pole. We approached the bird and upon close observation, identified it as an immature male (*F. C. richardsonii*). He remained on this pole for 2 or 3 minutes and then flew across the street to another pole. Remaining perched for less than one minute, he picked up a dead passerine with his beak, transferred it to his foot, and flew about 2 blocks northwest. He then landed on a tree squirrel's nest where he plumed and ate the prey item. Positive identification of the prey was not determined, but it appeared to be a redpoll (*Acanthis spp.*) or finch (*Carpodacus spp.*).

On December 19, 1977, between 1130 and 1230 hours, Pete Widener observed a female *richardsonii* Merlin (age undetermined) chasing and then killing a house Sparrow (*Passer domesticus*). The bird flew directly to a squirrel's nest with the prey where it began to plume the victim. Pluming was not completed when the Merlin cached this food item in the nest. The Merlin then flew to a nearby tree, where it perched for approximately ten minutes, rousing once and bobbing its head several times. Leaving this perch, it pursued another flock of House Sparrows, capturing one in the air. Returning to the tree from which it left, it began to bit the head and neck of the dead sparrow. The Merlin then returned to the same squirrel nest, cached this new food item, and flew off. Both caching episodes were conducted with the bird's beak, the feet being used only

to carry the item. After waiting there for 10 to 15 minutes, we ceased our observations.

Collins (1976) suggests that caching behavior is an adaptive advantage when seasonal abundance of prey exists. Thus, by stockpiling food either during nesting or at other times of the year, the individual ensures an adequate food supply. This type of behavior has been documented in wild and captive raptors. Tordoff (1955) and Mueller (1974) probably have the most definitive work regarding food caching behavior by the American Kestrel (*Falco sparverius*). Combined with known incidences of this behavior by the Peregrine (*Falco peregrinus*), Goshawk (*Accipiter* sp.), Secretary Bird (*Sagittarius serpentarius*), Lizard Buzzard (*Keupifalco monogrammicus*), Brown and Amadon (1968), Prairie Falcon (*Falco mexicanus*), (Oliphant and Thompson, 1976), and by a variety of tytonid and strigid owls (Collins 1976), one might consider this behavior to exist among all diurnal and nocturnal raptors.

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FLUCTUATIONS IN THE NUMBER OF NORTHERN HARRIERS (*CIRCUS CYANEUS HUDSONIUS*) AT COMMUNAL ROOSTS IN SOUTH CENTRAL OHIO

by

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Abstract

Eleven Northern Harrier (*Circus cyaneus*) roosts were studied in south central Ohio during the four winters of 1973-1974 through 1976-1977. They ranged from 8 to 59 birds. The number of birds using each roost fluctuated throughout the winter. While the abandonment of at least three roosts in midwinter can be attributed to severe weather, reciprocal fluctuations in the number of birds at nearby roosts and the direction of birds returning to one roost suggest that Northern Harriers will shift roost sites locally in an effort to maintain proximity to their hunting areas.

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Introduction

While the Northern Harrier (*Circus cyaneus*) is known to roost communally in Florida (Stoddard 1931), Indiana (Mumford and Danner 1974), Michigan (Craighead and Craighead 1956), Missouri (Weller et al. 1955), and New York (Clark 1972), there appears to be little quantitative data concerning their roosting behavior. This paper details fluctuations in the number of Northern Harriers at communal roosts in south central Ohio, noting especially the effect of the establishment of additional roosts nearby.

Methods

The study area was approximately 73 km² in south central Ohio along the Ross-Pickaway County line 16 km southeast of Circleville. The land is currently intensively farmed with little pristine habitat remaining except in small woodlots and along streams (Mills 1972). Small grain and livestock farms dominate the area.

From November to March 1973–1974 through 1976–1977 I found 11 communal harrier roosts, all that were present each winter (fig. 1), and estimated the number of birds using each. I rechecked each roost periodically (usually weekly and always within ten-day periods) to ascertain its size and status. Behavioral data were collected on six evenings and three mornings during the winter of 1973–1974 at one roost, on eleven evenings and five mornings during the winter of 1975–1976 at four roosts, and on six evenings and two mornings during the winter of 1976–1977 at three roosts. I spent 141.5 hours observing harrier pre- and post-roosting behavior.

During the winter of 1975–1976 I intensified my study and focused my efforts on roost 5 (see figure 1), following the behavior of its inhabitants from 9 November through 7 March. In the evening I arrived at roost 5 at approximately 85 min before sunset and stayed until after dark. For morning observations, I arrived 20 min before sunrise and remained until at least 100 min after sunrise. Observations were made from a pickup truck on a road or in a nearby field, usually at a distance of less than 0.25 km.

The flight directions of harriers leaving the roost in the morning and returning in the evening were noted. To reduce the possibility of recording a bird that was merely flying about, I recorded birds as approaching or leaving only if I was able to follow them for a flight distance of 0.5 km to or from the roost. I estimated the population of the roost by summing the number of birds seen entering or leaving the roost and comparing that number with the greatest number of birds seen over the roost at one time. The larger number was added to birds I intentionally flushed from the roost either prior to evening or following morning observations. Birds flushed from the roost in the evening quickly re-roosted and were not counted twice in population estimates.

Results

Table 1 summarizes the number and species of birds using each roost and the period of time the roost was active. All roosts when initially found, usually in the fall or early winter, contained fewer than 20 birds.

Northern Harriers roosted with the Short-eared Owl (*Asio flammeus*) at seven of the eleven communal roosts. The remaining four roosts were small (each less than 15 birds) and did not remain active long (each less than one month). I also saw harriers roosting singly on the study area; these single bird roosts remained active for less than four nights.

Although there appeared to be no preference for high ground in the selection of

roosts, roost 1 was abandoned when low-lying areas of the field were covered with melt water after a severe snow and ice storm. Similarly, roosts 9 and 10 were abandoned following a snowfall of 15–18 cm during the preceding 36 hours. Mois (1975) notes comparable weather-dependent roost abandonments in his study of *C.c. cyaneus* in Belgium. Harriers flew over these roost fields later in the winter, but my attempts to flush any from them were futile. In addition to those 3 roost abandonments, 5 of the remaining 8 communal roost sites were also deserted during midwinter before harriers left the study area. Moreover, all the communal roosts fluctuated in the number of birds using them, with the number of Short-eared Owls and Northern Harriers at a roost seeming to fluctuate independently.

Table 1. Description of Eleven Northern Harrier Roosts Studied

Roost number (winter)	Maximum number of birds using the roost		Minimum duration of roost activity
	Northern Harriers	Short-eared Owls	
1 (1973–1974)	40	12	12 Jan. 1974 to 19 Jan. 1974
2 (1974–1975)	30	12	30 Nov. 1974 to mid-March 1975
3 (1974–1975)	17	5	14 Dec. 1974 to 10 Jan. 1975
4 (1974–1975)	8	0	11 Jan. 1975 to 8 Feb. 1975
5 (1975–1976)	45	14	9 Nov. 1975 to mid-March 1976
6 (1975–1976)	12	0	10 Nov. 1975 to 30 Nov. 1975
7 (1975–1976)	25	4	2 Jan. 1976 to mid-March 1976
8 (1975–1976)	7	0	11 Jan. 1976 to 30 Jan. 1976
9 (1976–1977)	15	10	18 Nov. 1976 to 10 Jan. 1977
10 (1976–1977)	16	9	23 Dec. 1976 to 10 Jan. 1977
11 (1976–1977)	8	0	19 Feb. 1977 to mid-March 1977

At roosts 2 and 5, 10–12 Short-eared Owls were present from mid-November through mid-December. Their numbers declined to 2 birds and remained so through early January. By late January there were 8–12 owls at each roost, and they remained there through the end of February. Fluctuations in the number of hawks using a roost, with one exception, followed one of two trends: either the number of birds at

the roost continued to increase slowly with a maximum number occurring in late winter, or the number of birds at the roost remained at less than 20 for several weeks, then declined rapidly to 5–10 birds that subsequently abandoned the roost *en masse*. The one exception was roost 5 which lost birds rapidly, but remained active for an additional 2 months.

Fluctuations in the number of harriers using roosts 5, 6, and 7 (fig. 2) show what happened when one of 2 neighboring roosts grew larger and when a new roost was established near an existing one. On 10 November 1975, roosts 5 and 6 were being used by 11 and 10 harriers, respectively. Twenty days later, roost 6 ceased to exist, and roost 5 almost doubled in size. Similarly, within 20 days of the establishment of roost 7, the number of birds estimated to be using roost 5 declined from 45 to less than 20. The same phenomenon occurred between roosts 2 and 3 during the winter of 1974–1975. With the establishment of roost 3 in mid-December 1974, roost 2 declined in numbers within 2 days from an estimated 25–30 harriers to 10–15 birds.

The establishment of a new roost was signalled by the birds drifting toward the new area in the evening. This pre-roosting behavior occurred over a broad band between the two roosts. At the time of actual roosting the birds separated and went to one or the other roost; there was no commingling in the morning during the predeparture period.

I monitored the direction of arrivals and departures at roost 5 before and after the establishment of roost 7, 1.4 km to the WSW (fig. 1). Before roost 7 was established, harriers departing from roost 5 dispersed randomly ($P > .10$; Kolmogorov test with Kuiper's adjustment for circular distributions; Batschelet 1965; Figure 3A). After roost 7 appeared, a Rayleigh test (Batschelet 1965) indicated a unimodal distribution of departures from roost 5 ($P < .01$) with a preferred departure direction to the ENE (mean direction 61°), opposite the direction of roost 7 (fig. 3B). Before roost 7 was established, although harriers returned from all directions a significantly greater proportion came from the SSE ($P < .01$; Rayleigh test; mean direction 156° ; Batschelet 1965; Figure 4A). After the second roost appeared, the directional distribution of arrivals did not differ significantly from a uniform distribution ($P > .05$; Kolmogorov test with Kuiper's adjustment for circular distributions; Batschelet 1965; Figure 4B).

Discussion

While it is likely that severe weather caused abandonment of roosts 1, 9, and 10, all the communal roosts fluctuated in numbers. I suspect that these latter fluctuations reflected local prey availability. My observations strongly suggest that roost site selection results from a compromise among the birds using the roost. It appears that in the fall, as single birds arrive, they roost on or near the areas they hunt. As more birds arrive, the tendency to roost together leads birds to select communal roost sites equidistant from their hunting areas. The result is a general trend toward increasingly fewer roosts with more birds at each as the season progresses. Clark (1975) reports a similar seasonal progression in the size of the Short-eared Owl roost he studied. Both Mumford and Danner (1975) and Weller et al. (1955) reported centrally placed roosts: The harriers they studied returned to communal roosts from all directions. Similarly Craighead and Craighead (1956) recorded Northern Harriers "fanning out each morning" from the roost they studied. Meinertzhagen (1956) notes a similar evening rendezvous for the communal roosting harriers *C. aeruginosus* and *C. pygargus* he watched. Thus, as long as the roost is central to a number of good hunting areas, it will continue to attract birds and in-

crease in size. But as the winter progresses and prey becomes less readily available in certain hunting areas, harriers dispersing from the roost to those depleted areas will have to move elsewhere to hunt successfully. This is supported by my observations of hunting harriers as well as those of Craighead and Craighead (1956) who found that winter ranges of harriers "approach a condition of continuous drift" when prey populations are low. The departure and arrival directions of harriers at roost 5 prior to the establishment of roost 7 illustrate this phenomenon. While birds were dispersing randomly from roost 5, I suspect some were flying into prey-depleted areas. These birds would be forced to move on in search of better hunting areas, the majority of which were apparently located SSE of the roost. This explains the nonrandom direction of birds returning to roost 5 prior to the establishment of roost 7. With the establishment of roost 7 (presumably by birds from roost 5) 1.4 km to the WSW, the direction of birds returning to roost 5 became random. Apparently some roost 5 birds, those whose hunting areas were to the south of roost 5, established a new roost (7) that was for them more central to their new hunting areas. The birds that remained in roost 5 did so because it was more centrally located to their hunting areas as is shown by the directions of returning birds. Morning departure directions from roost 5, which became nonrandom following the establishment of roost 7, possibly indicate that harriers departing from a roost tend to avoid other harriers departing from a second roost (7) nearby.

Acknowledgments

This paper is based on part of a thesis submitted to the Department of Zoology, The Ohio State University, in partial fulfillment of the requirements for the Master of Science degree. I thank F. and F. N. Hamerstrom and T. C. Grubb, Jr., for their critical reading of the manuscript. Fieldwork was supported in part by funds from the Ohio Biological Survey and the Department of Zoology, The Ohio State University.

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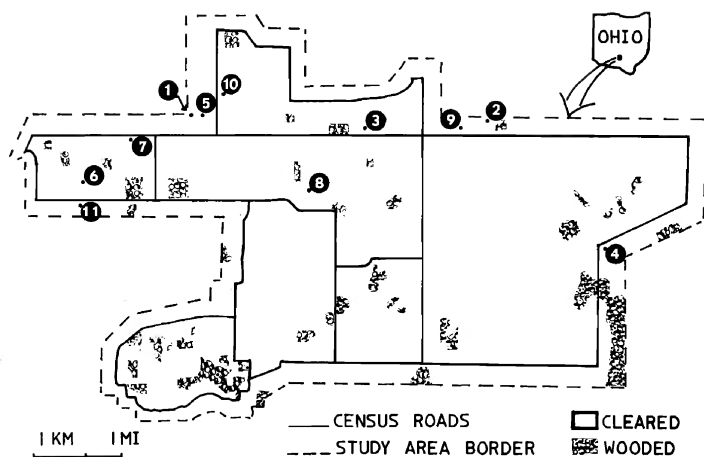


Figure 1.—Locations of the eleven Northern Harrier roosts studied. Harriers were seen hunting throughout the study area.

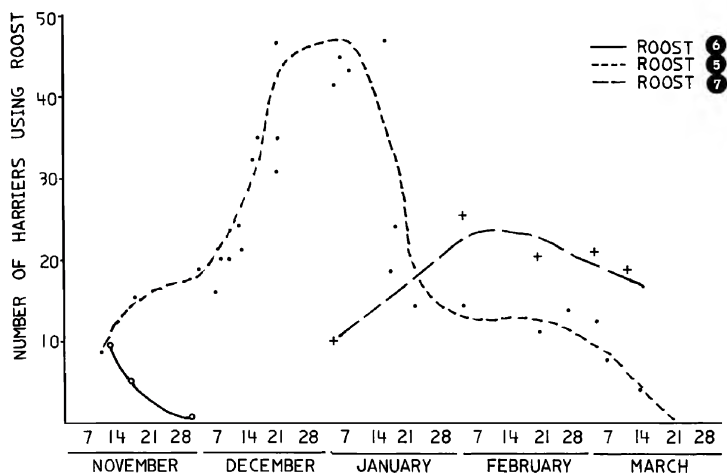


Figure 2.—Relation between the establishment of a second Northern Harrier roost nearby and the size of an existing roost.

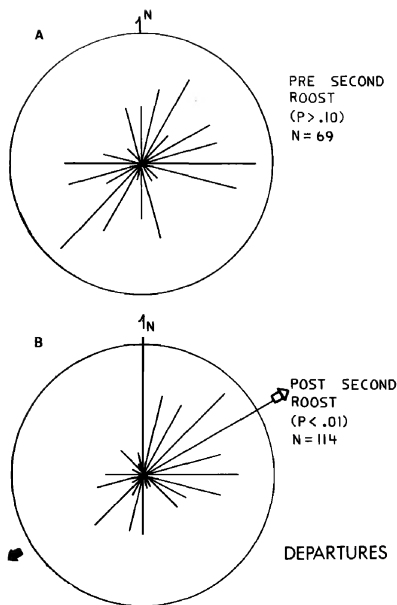


Figure 3—Directions of Northern Harriers departing from roost 5 before (A) and after (B) the establishment of roost 7. Filled arrow indicates direction of a significant unimodal distribution. The circle represents a relative frequency of 10 percent. Probabilities of significance were found with a Rayleigh test (Batschelet 1965).

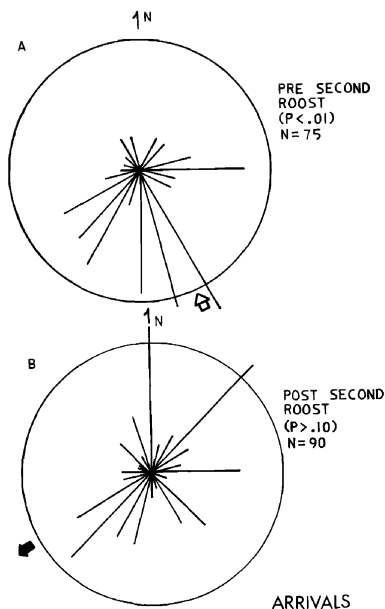


Figure 4—Directions of Northern Harriers arriving at roost 5 before (A) and after (B) the establishment of roost 7. Filled arrow indicates the direction of roost 7; open arrow indicates mean direction of a significant unimodal distribution. The circle represents a relative frequency of 10 percent. Probabilities of significance were found with a Rayleigh test (Batschelet 1965).

USE OF CABLE IN FERRUGINOUS HAWK (*BUTEO REGALIS*) NEST

by

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Ferruginous Hawks commonly construct nests of sticks up to one inch in diameter which are taken from shrubs such as juniper, shadscale, and sagebrush around the nesting site (Weston 1969:29). Cow or horse dung and paper are apparently not uncommon nest materials, and old rubbish and bones are sometimes used (Bent 1937:285-287). Barbed wire, corn stalks, and plastic have also been reported to be minor parts of nests (Lokemoen and Duebbert 1976). An unusual piece of rubbish was used in construction of a Ferruginous nest, containing two large, half-fledged young and one addled egg on 10 June 1974, located near U.S. Highway 6-50 in Skull Rock Pass, Millard County, Utah, 49 miles (78 km) southwest of Delta. A 2-foot (0.6 m) length of ½-inch (1.3 cm) steel cable, presumably from a construction site about ½ mile (0.8 km) from the nest, was interwoven into the nest structure (fig. 1). The nest location (fig. 2), atop a 15-foot (4.6 m) boulder (The Skull Rock) in a shadscale (*Atriplex*) community, may have been deficient in the large sticks typically used in nest construction but did provide the isolation necessary for nesting success of this species.

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Figure 1. Ferruginous Hawk nest in Millard County, Utah.



Figure 2. Ferruginous Hawk nest showing 1.3 cm steel cable interwoven with coarse sticks in nest.

BOOK REVIEW

Working Bibliography of the Bald Eagle

J. L. Lincer, W. S. Clark, M. N. LeFranc, Jr., Raptor Information Center of the National Wildlife Federation, Washington, D.C.

Being an avid bibliophile, I always take a keen interest in new lists of references on raptors no matter how short or long. In the Raptor Information Center's *Working Bibliography of the Bald Eagle* interest is even greater, because this keyworded compilation of 2,000 Bald Eagle references sets the highest of standards for cataloging the available information on a raptor species. Only the prohibitively time-consuming task of annotating or abstracting each entry would be an improvement. Unfortunately, the backruns of journals are too long and the current proliferation of literature is too great to allow the luxury of annotation for extensive bibliographies greater than 300–500 entries.

In many ways this work is even more than a bibliography on Bald Eagles. Sections on the status of the species (both present and historical), current research, and an introductory chapter on taxonomy, distribution, life history, limiting factors, and management add to its utility.

But the essence of the bibliography is the Master List of Citations (which is remarkably consistent and accurate) and the Permuted List of Keywords. Each entry of the keyword list includes all of the words used to describe a particular citation. The keywords are rearranged several times so that each becomes the first in the series, thereby creating a new entry for the list. If a citation has seven keywords, it appears in the Permuted List seven times, alphabetically by each keyword.

This system takes considerable space (over half of the book), but the accessibility it provides is worth the effort and cost, provided it can be created by computer as was the case here. In short, the compilers are to be commended for producing such an innovative and excellent reference book. And, as if that was not enough, they also collected each and every entry—the original or a photocopy—and placed them on file at the Raptor Information Center. Indeed, the data based on the Bald Eagle has been established, and its accessibility has been increased beyond measure.

Richard R. Olendorff

ANNOUNCEMENTS

Research has been conducted on the raptors of northwestern Connecticut for four years now. The focus of the study has been on the goshawk, red-shouldered hawk and the barred owl. Nests of red-tailed hawks, Cooper's hawks, broad-winged hawks, great-horned owls, saw-whet owls and American kestrels have also been found. Data on habitat preference, prey utilization, nesting success, and productivity are being taken.

Most of these species occur and nest in parts of the east and we would like to compare our findings with others who are locating any nests of raptors in this section of the country.

An information exchange with notes on one species or a comparison of general raptor populations of an area would be ideal. Also any attempts, successful or not, at using artificial nesting structures would be of interest.

Address letters of inquiries to Michael Root or Peter DeSimone, Miles Wildlife Sanctuary, West Cornwall Rd., Sharon, Ct. 06069.

Mississippi Kites are being marked with colored leg bands and patagial tags in western Kansas and Oklahoma, and north-central Texas. Each kite carries a Fish and Wildlife band and from one to three additional color bands in combinations of red, blue, green, yellow and silver. Kites captured as adults also wear a pair of plastic patagial streamers on the dorsal surface of the wings. Streamer colors are red, dark blue, light blue, orange, yellow, and green; and about one inch of each streamer extends beyond the ends of the secondary feathers. Persons observing the marked kites are requested to send as much information about the kite and its situation as possible to, Chief, Bird Banding office, Office of Migratory Bird Management, Laurel, Maryland, 20811. Please send a copy plus any additional information to the bander, James W. Parker, Biology Department, State University College, Fredonia, New York, 14063.

HAWK TRUST CONFERENCE

The scientific committee of the Hawk Trust organized the Conference on Birds of Prey at the offices of the Zoological Society of London on November 4, 1978.

The theme of the conference was behavioural ecology. Principal speakers were N. Picozzi, D. N. Weir, A. R. Hardy, D. C. Houston, and N. Fox; and the subjects covered included sex-ratios in hen Harriers in Orkney, predation by Peregrines, territory usage by Tawny Owls, the role of Vultures, and a general paper on hunting strategies.

In the afternoon a session of short communications dealt with a variety of topics. Particular interest was shown in studies on the reestablishment of the Goshawk in Britain and an interim report on his work on the Kestrel by James Kirkwood, the Hawk Trust research fellow.

In his summing-up of the conference, Professor V. C. Wynne-Edwards paid tribute to the high quality of the research and presentation and suggested that this represented a landmark in raptor studies.

The proceedings will be published in due course and can be obtained from the Hawk Trust, P.O. Box No. 1, Hungerford, Berks., England.

EXTENSIVE RAPTOR BIBLIOGRAPHY FOR SALE

Ever since *An Extensive Bibliography on Falconry, Eagles, Hawks, Falcons, and Other Diurnal birds of Prey* was published (1968-71), people has expressed an interest in a set of indices. The long and tedious compilation of subject, species, and periodical indices for the 7,500-entry bibliography is now complete and available for \$6.00 (postpaid) from Richard R. (Butch) Olendorff, 6009 Viceroy Way, Citrus Heights, California 95610. If you own one of the 1,000 copies of the original edition, be sure to complete it by purchasing the indices. Quantities are limited.

In addition, a limited edition of 130 hard-bound copies of the *the entire bibliography plus the indices* has been published. Only 65 copies of this handsomely bound 286-page book remain (as of Feb. 1, 1979) for sale for \$30.00 each (postpaid)—also from Olendorff (address above). This will be your last chance to obtain the standard and most extensive reference bibliography ever produced on the diurnal birds of prey.

NEST ROBBING AND FOOD STORING BY NEW ZEALAND FALCONS (*Falco novaeseelandiae*)

by

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Abstract

New Zealand Falcons at hack (i.e., controlled liberty) or in the wild were seen attempting to rob nests or to capture fledging young on at least 11 occasions. Food storage or retrieval was seen in numerous instances in 8 captive or semicaptive falcons and 13 wild pairs. Common situations in which these behaviors were seen are outlined, and the significance of food storage in raptors is discussed.

Introduction

Nest robbing and retrieving of stored food are similar activities which are often difficult to distinguish between in the field. Nest robbing has been seen in the American Kestrel (*Falco sparverius*) by Bonnot (1921), Bishop (1925), Drinkwater (1953), and Richards (1967); in Lanner Falcon (*Falco biarmicus*) by Sinclair and Walters (1976); and in Peregrine Falcon (*Falco peregrinus*) by Clunie (1976). Nest robbing has also been seen in accipiters such as the Coopers Hawk (*Accipiter cooperii*) (Linduska 1943, Nelson 1968), the Northern Goshawk (*Accipiter gentilis atricapillus*) (Schnell 1958), the Gabar Goshawk (*Melierax gabar*) (Kruuk and Voous 1966, Kluyver 1966) and the Pale Chanting Goshawk (*Melierax canorus*) (Smeenk and Smeenk-Enserink 1976). Lowe (1940) recorded the African Harrier Hawk (*Polyboroides typus*) as killing nestling birds. This latter is more fully documented by T. Thurow (ms and pers. comm.).

Henry (1903) was the first to mention nest robbing in the New Zealand Falcon (*Falco novaeseelandiae*). He wrote: "The hawk used to fly through the trees where the nest were, and seldom failed to carry something off in his claws." He did not specify whether the prey was adult or young.

Field Observations

New Zealand Falcons were seen attempting to rob nests on 5 occasions. On 4 occasions an adult male nesting at hack attempted to enter Starling (*Sturnus vulgaris*) nests in tree hollows or in holes between bales of hay. Each time he flew directly to the hole and, clinging to the rim, tried to pull the young out with his beak, but was unsuccessful. Prey remains indicated that he managed to take several young starlings as they left the nest and started to fly. On another occasion a different adult male at hack detected an occupied House Sparrow (*Passer domesticus*) nest by the cheeping of the chicks. The nest was in the rafters of an open tractor shed. The falcon flew up, clinging to the beam, pulled the nest open, and extracted one of the young sparrows. On another occasion a pair of feral Rock Dove (*Columba livia*) were nesting in the rafters of an open barn, inaccessible to ground predators. The day after the eggs hatched, the squabs disappeared. Although the falcon was not seen to take the young, he regularly roosted in

the rafters only 3 m from the nest, and the pigeons reared young successfully once he was removed.

Wild New Zealand Falcons were not seen actually robbing a nest although remains of young nestlings, some still naked, were found at several eyries (Fox 1977: 90).

Although not actual nest robbing, on one occasion a wild adult male systematically caught and ferried away a brood of Yellowhammer (*Emberiza citrinella*) which had just left the nest. As in the Goshawk described by Schnell (1958), the falcon returned to the raided nest area until no more young were found. Also on 5 occasions falcons caught in my study penetrated deep into hedges and bushes to capture newly fledged young birds, ignoring the scolding parents only a few centimeters away.

Food Caching

Although food caching has been recorded in the accipiters (Selous 1911, Owen 1931, Schnell 1958), in a Ferruginous Hawk (*Buteo regalis*) (Angel 1969), and in a Crowned Eagle (*Stephanoaetus coronatus*) (Brown 1971), reports of hiding prey are more common for owls and falcons. Kaufman (1973) and Collins (1976) recorded food caching in a number of owl species. Townsend (1930), Pierce (1937), Tordoff (1955), Stendall and Waian (1968), Mueller (1974), and Balgooyen (1976) noted food hiding in American Kestrel; Greaves (1968) and Oliphant and Thompson (1976), in the Merlin (*Falco columbarius*); Vaughan (1961), in Eleanora's Falcon (*Falco eleanorae*); Beebe (1950), in Bat Falcon (*Falco rufigularis*); Peterson and Sitter (1975), in Prairie Falcon (*Falco mexicanus*); and Beebe (1960) and R. W. Nelson (pers. comm.), in Peregrine Falcon.

New Zealand Falcons showed a marked tendency to cache prey at all times of the year. Eight falcons studied in captivity or at hack all had a strong caching habit. It was so marked that, after a trained falcon had killed prey, it would usually hide it and continue hunting. This was in normally keen hunting birds and was contrary to expectations (see Mueller 1973). One falcon caught, killed, and hid five House Sparrows in a row without eating any of them. Food storage was frequent in the wild too; at least 13 wild pairs of falcons were seen hiding or retrieving cached food (fig. 1).

New Zealand Falcons hid prey in much the same way as described for other species. The site was approached furtively, and the prey thrust into place with the beak. Items apparently were not placed in any preferential position such as belly-downwards, as described by Tordoff (1955) and Balgooyen (1976). After positioning the item, the falcon would then run a few steps and examine the site as if inspecting or memorizing the location (Mueller 1974). If not satisfied the falcon occasionally would extract the prey and adjust it or hide it somewhere else. The commonest locations for caches were small (30–100 cm high) bushes, the prey being thrust in from above or from the side. Tussocks, tree-stumps, and small (3–4 m) trees were also used. Taller trees were also used regularly where available. Some of the bushes were too dense and thorny for me to insert my hand, and yet I saw the falcons squeeze in right out of sight.

The length of time each prey was stored was not determined, but overnight storage was frequent. One item was retrieved 10 days later by a hack falcon. Only one item was ever seen in one cache at any one time, but the same tree or bush was sometimes used repeatedly, on an irregular basis. Although a particular falcon usually retrieved only from its own store, during courtship the female often raided the male's caches—an activity known as "remote food passing" (Nelson 1977, Fox 1978).

The commonest situations in which caching occurred were:

- a. If an adult male returned to the nest area with prey and met with no response from the female, he usually hid the prey.
- b. If the female had fed chicks and herself and still had some food left over, she cached it 20–100 m from the nest.
- c. If the male had been hunting and returned unsuccessful, he might then extract stored prey to give to the female.
- d. If the male returned to the nest with prey and saw an intruder, he would retire and hide the food before commencing nest defense (see Schnell 1958).
- e. If several vulnerable prey were found, the falcon would kill one and cache it, then return for the others, one by one.
- f. Remote food passing.

Falcons usually approached the cache directly when retrieving food. But on at least 8 occasions falcons landed within 5 m of the food and spent up to 7 min. searching for the location. The falcons' imprecise knowledge may have been because a different falcon had originally stored the food while the retrieving falcon had watched from some distance away, or because the falcon had stored the food there some time before and all the bushes looked similar. Also, in the field it was difficult to detect whether the food was retrieved and previously killed food or freshly killed from a raided nest (a "living food cache"). Falcons at hack appeared aware of the nesting activities of other birds and checked nest bushes with persistent regularity.

The Significance of Food Caching

Cache appears to take place only when food is abundant. I have found no records of food storing when prey was scarce. C. M. White (pers. comm.) described how a migrating American Kestrel repeatedly killed migrating Kinglets (*Regulus* sp.) and hid them, moving on at the end of the day having stored 7 Kinglets with no obvious intention of returning. Sea-cliff nesting Peregrines, preying on sea-bird colonies, often store excess prey during the breeding season. All my observations of food caching in New Zealand Falcons have been of birds with a secure food supply. Even trained birds seemed to be aware that they would be fed whether they killed or not.

Food storage may make use of prey which is temporarily abundant or available to tide over periods when prey is less available. R. W. Nelson (pers. comm.) noted that Peregrines (*F.p. pealei*) nesting near colonies of the Ancient Murrelet (*Synthliboramphus antiquum*) appeared to live entirely on cached prey. The male was presumably killing the murrelets as they left the colony at dawn and then caching them for daytime use when the murrelets were away at sea.

New Zealand Falcons became lethargic during the oppressive midday summer heat and appeared reluctant to hunt. Active flapping flight, especially carrying prey, was reduced at this time, and cached prey were often used. In hot weather cached prey quickly becomes unusable; Nelson (pers. comm.) observed a Peregrine retrieving and rejecting a stale food item. Stored prey in a New Zealand summer usually contained active fly larvae after 24 h and would become unpalatable to the falcons after about 48 h. Natural decay and infestation thus greatly limit the value of stored food for use during prolonged bad weather and encourages the theory that caches are used mostly for temporary drops in prey availability. The Barred Owl (*Strix varia*) cache food early in the morning just before they stop hunting for the day. The stored food is retrieved in the early evening, before the main prey species have become really active or available (C.

M. White pers. comm.). Food storage may be more important for owls because they have no crops and because mammalian predators are less active during the daylight period when owl prey is in the cache.

The theory that caching has an adaptive advantage during periods of bad weather is an obvious but speculative one. R. W. Nelson (pers. comm.) considered that the Peregrine he studied had about 2-3 days' supply stored. This would be of especial use to this subspecies which lives in a wet and foggy climate. But caching may not be as advantageous as first appears; I found that hunting success with trained Northern Goshawks was, if anything, improved in rain, fog, wind, or falling snow. New Zealand Falcons retired to dry perches when it rained, but they would sally out if they saw a good attack opportunity. The small-bird prey species have a high metabolic requirement which takes a considerable portion of the day to satisfy, and they are thus extra vulnerable when out in the rain collecting insects or seeds. Prolonged bad weather could affect raptors by:

- a. covering ground prey such as mice and lizards with a protective blanket of snow,
- b. reducing prey populations to low levels owing to death or migration,
- c. weakening some prey and making them more vulnerable,
- d. covering hidden prey with snow (Snowy Owl, *Nyctea scandiaca*, sat on prey or carried it rather than caching it, in Wisconsin, [F. Hamerstrom pers. comm.]).

Thus caching may not have so much significance during prolonged winter weather as first thought.

It seems probable that the only reason food caching is prevalent in the New Zealand Falcon is that this species has evolved in the absence of mammalian predators capable of locating cached prey by scent. Now that cats, dogs, and mustelids have been introduced in New Zealand, food storage is probably less advantageous to New Zealand Falcons. On several occasions when falcons were at hack on the farm, our cat was seen actively to search for and raid the falcons' food stores, and a 20 m radius around one nest in the wild was completely rooted up by wild pigs (*Sus scrofa*), presumably searching for hidden falcon prey. Thus caching behavior in other parts of the world would have less adaptive benefit for falcons except perhaps when there is a pressure exerted on them to maintain a steady food supply during the breeding season.

The possible adaptive advantages of food caching may be summarized as follows:

- a. maintains food supplies during temporary low prey availability.
- b. maintains food supply during irregular stress periods, e.g. bad weather.
- c. may reduce parasite infections from prey.
- d. may reduce nest predation.
- e. acts as a stage in the development of the food pass during courtship.

In evolutionary terms food storage during the nonbreeding season may be relict behavior in most falcon species, or it may be that observations of the more wary falcon species have so far been inadequate. Shy falcons, especially in winter, may be reluctant to hide food if they know they are being watched.

Acknowledgments

These observations were made during a wider study of New Zealand Falcons sponsored by the Drapers Company, London. I would like to thank Drs. J. Warham, C. M. White, R. W. Nelson, and F. Hamerstrom for their criticisms and helpful information.

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Figure 1.—New Zealand Falcon in act of retrieving cached food.

SOME OBSERVATIONS ON THE BEHAVIOR OF CAPTIVE BALD EAGLES BEFORE AND DURING INCUBATION

by

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Abstract

Preincubation and incubation behavior were studied in two pairs of captive Bald Eagles. During the preincubation period, perching together, nest building and repairs, copulation, mutual billing and stroking, courtship feeding, and pseudoincubation were observed and described, and the frequency was quantitated. During incubation, activities concerned with nest maintenance, nest relief, and feeding were observed and quantitated. The time the Bald Eagles left the eggs exposed during incubation varied significantly with changes in the ambient temperature and wind velocity. A significant correlation was found between the average time the eggs were left exposed (min/h) and the wind chill index, with eggs being exposed least when the cooling power of the air was the greatest.

Introduction

With increasing interest in captive propagation of Bald Eagles (*Haliaeetus leucocephalus*) and other raptors as a means of aiding declining wild populations (Hancock 1973, Cade 1974, Maestrelli and Wiemeyer 1975), there is a need for better understanding of preincubation and incubation behavior. Such behavior in Bald Eagles has been briefly described by Herrick (1934), Broley (1952), and Retfalvi (1965) in wild birds and in captive birds in a review by Hancock (1973). For some other raptors, more detailed documentation is available (Willoughby and Cade 1964, Fyfe 1972, Grier 1973, Wrege and Cade 1977). In the present investigation, we have made use of the opportunity provided by the captive breeding of Bald Eagles at Patuxent Wildlife Research Center (Maestrelli and Wiemeyer 1975) to evaluate at close range certain aspects of the early phase of their nesting cycle.

Methods

Three pairs of Bald Eagles were caged in three identical adjoining pens as described by Maestrelli and Wiemeyer (1975). Two of these pairs were used for the present study. Each pen had screened sides and top, with translucent fiberglass roofing over the nest area. The eagles were fed through small doors at the front of the pen usually between 08:00 and 10:00. A mirror above each nest made it possible to see the eggs in the nest from the front of the pens.

Detailed observations, with little disturbance to the birds, were made on the 2 pairs from 19–24 March 1973 from a blind about 120 m southeast of the pens. The observations usually extended from dawn to dusk with periodic ½-hour or 1-hour breaks. From the blind, the view of the nests and upper perches was good, but because of the intervening pens, the lower perches and floor were out of sight. We used a 45× spotting scope and 7 × 35 binoculars. Written minute-by-minute records were kept of observations. Wind direction and estimated speed were recorded hourly.

History of the Birds

Pair I had been together since December 1969. The female was obtained from Ala-

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bama where she was found injured beneath a high voltage line, when she was, by plumage, about three years of age. The male was obtained as a nestling from Alaska. In 1971, at least two eggs were laid with the one which was intact when examined after 56 days of incubation being infertile. In 1972 this pair successfully incubated three fertile eggs, but unfortunately two newly hatched eaglets died after an April ice storm, and the third egg failed to hatch. In the spring of 1973, this pair again built a nest and were seen copulating. The female laid eggs on 26 February, on 1 March, and on about 5 March. Our observations occurred during mid-incubation from 19–24 March 1973. Further details of the history of this pair and their success in raising young eagles in 1973 are published elsewhere (Maestrelli and Wiemeyer 1975).

Pair II had also been together since December 1969. The female came from Passamaquaddy Bay, Maine, as a bird of the year in June 1966. The male was taken from Alaska as a nestling in 1962 and was hand raised at the Center (Stewart 1970). This male was partly crippled, being unable to fully extend his wings. In 1971 the female laid at least one egg during the first week of April on the partially exposed nest platform (little nest material had been added to the man-made nest). Copulation was not observed, but both adults took part in incubation. The egg broke by 26 April. In 1972 the female laid two eggs, the first on 31 March. The adult had added dry grass to the nest, thus improving it from the previous year. Both adults again participated in incubation and became aggressive towards humans after the first egg was laid. Both eggs had broken by 23 April; it was not known if they were fertile. In 1973, during the week before the observations reported in this paper, this pair of adults had been observed adding sticks to the nest. During our study, 19–24 March, this pair exhibited preincubation behavior. The female laid two eggs; the first on 26 March. The eggs were incubated until 7 May when they were removed from the nest. No embryonic development was detected in either egg.

Preincubation Behavior—Pair II

Perching together

During 6 days of observations, Pair II adults were observed perching side by side (within 3 feet of one another) on 35 occasions for 619 minutes during daylight hours. On 3 of the 4 evenings when we observed until dusk, the 2 eagles remained perched together until it was too dark to see. On 16 of the 35 occasions when the two eagles perched together, behavior preliminary to and sometimes including copulation was observed. During the periods of perching that were not associated with copulation or copulation preliminaries, they often looked at each other, sometimes called to one another, but mostly napped, looked around, or preened.

Copulation

Behavior preliminary to and/or including copulation was observed on 16 occasions (fig. 1). Seven of these occurred between 07:00 and 9:00. The rest were scattered throughout the remainder of the day. The behavior always began with a period of perching side by side. After having perched together for 1 to 32 minutes (mean = 17.5 min) one bird approached the other. The female approached first 8 of 16 times. She lowered her head, spread her wings slightly, and moved toward the male, opening and closing her beak appearing to call. Usually this calling was inaudible from the blind. When heard, it was a single, soft, high-pitched note repeated several times, very different from calls used on other occasions. She would then move her head near his wing

and nudge him (fig. 1a). When the male made the approach he hopped near her and then edged closer, sometimes calling in a similar fashion (fig. 1b). Following the initial approach by the female, the male called, then flapped his wings and moved his tail up and down (usually lowering his body and hitting the perch with his tail). When the initial approach was made by the male, the female positioned herself with feet further apart, head lowered, and wings slightly apart (bowing), ready for the male to mount her (fig. 1c). On 10 of 16 occasions, the copulation preliminaries proceeded no further.

On 6 occasions the male stepped with balled feet onto the female's shoulder and then onto her back flapping his wings and calling loudly as he did so. On 4 of these occasions, he stepped across her back and perched on the other side of her. Twice he stayed on her back several seconds lowering his body until it was flush with her back. Her tail went up and his went down (fig. 1d). He seemed to have great difficulty in maintaining his position on her back because of his inability to completely extend his wings and the resulting difficulty with flapping and flying. The first time the complete sequence was seen, the male appeared to fall off her back and land on the perch. He immediately remounted and stayed on her back longer than before, but again appeared to fall off, this time landing on the ground.

After preliminary or complete copulation behavior, the eagles remained perched next to one another 0 to 37 minutes (mean = 9.4 min). Either immediately or after a short period of perching together, the male or female or both usually (9 of 16 times) went to the nest and arranged nest material. On 6 occasions one or both birds spent considerable time preening.

Nest-associated activities

The male spent 722 minutes of 51 complete hours of observations on the nest (mean = 14.2 min/h; range 0–47 min). The female spent 621 minutes on the nest (mean = 12.2 min/h; range 0–60 min). For 70 minutes the eagles were on the nest together (mean = 1.4 min/h; range 0–14). The female spent more time in incubation posture (pseudoincubation—there were no eggs at this time) than the male. She averaged 7.7 min/h (range 0–33 min) while he averaged only 2.6 min/h (range 0–40 min). The male spent more time (total 89 min; mean 1.7 min/h; range 0–6 min) arranging sticks and grasses on the nest than the female (total 56 min; mean = 1.1 min/h; range 0–19 min).

Behavior relating to arranging nest material and assumption of incubation posture was very similar to that of pair I (see below) with 2 exceptions. First, pair II adults spent more time poking and jabbing in the center of the nest with their beaks. Second, pair II adults were much less consistent in their behavior during assumption of incubating posture. Pair I adults invariably arranged nest material and/or poked in the nest center, then rocked from side to side as they settled into the nest to incubate, and then pulled twigs and branches around them to form the nest cup. The pair II adults often left out one or more steps in this sequence.

Billing and mutual stroking

Billing (pecking at each other's beaks), and stroking each other were observed 10 times. Billing alone occurred 5 times, and stroking accompanied billing on the remaining occasions. During stroking episodes, the female was observed to stroke the male with her beak on his back and breast, while the male stroked the female on her head, neck, and shoulder. All but two of these episodes occurred before 08:00 or after 17:00.

Feeding

Feeding was seen on 4 days. Once the male carried a fish to the nest where both adults ate together. Usually the male went down to feed first, followed by the female.

Incubation Behavior—Pair I

Incubation

Pair I was observed for 55.5 hours, of which 48 hours were complete hourly periods. At least one adult was on the nest 99.5 percent of the time, and the eggs were incubated 98.0 percent of the time (table 1). When the weather was cold and the wind stronger, the incubating adult sat low in the nest with head pulled in near the body and feathers fluffed out. On warmer days with little wind, the adults sat higher in the incubating position.

The amount of time the eggs were left exposed varied with both ambient temperature and wind velocity. The eggs were left exposed significantly longer (Mann-Whitney $U = 390$; $p < 0.05$) when the air temperature was greater than 7.2°C (mean 1.72 min/h)

Table 1. Captive Bald Eagle Nest Activities—Pair I

Activity	Time spent—mean min/ ¹		
	Male	Female	Both together
Incubating eggs	16.6	42.0	—
Poking in the nest, moving eggs, and/or arranging nest material	1.0	1.2	—
Total time spent on the nest	18.3	43.3	2.2

¹Based on 55.5 h of observation.

than when the air temperature was equal to or below 7.2°C (mean = 0.56 min/h). When the wind velocity was less than 16.2 km/h, the eggs were left exposed an average of 2.17 min/h, whereas with higher wind velocities the eggs were left exposed only 0.64 min/h; the difference is significant (Mann-Whitney $U = 444$; $p < 0.05$).

The length of time the eggs were left exposed was also related to the wind chill index (fig. 2). The time the eggs were left exposed was highly variable within a small range of wind chill index values. There was, however, a significant linear correlation ($r = 0.977$; $p < 0.05$) between the wind chill index values averaged for each 100 unit wind chill interval and the average time (min/h) the eagles left the eggs exposed.

Arranging nest materials

Both adults carried materials up to the nest. These varied from large sticks to grasses. Large sticks were usually brought to the nest by the relieving adult. After arranging the sticks on the nest, the adult then took over incubation. Several times both adults worked together in placing a large stick. Almost invariably there was some poking in the nest just before assuming the incubation posture in the nest relief sequence. This poking consisted of a gentle probing into the nest cup, similar to that seen by us (NG and JMG) when a Red-tailed Hawk was shifting its eggs. On some occasions grasses and twigs in

the nest may also have been arranged during this process. On two separate occasions, a very different action was seen. the adult pecked hard and rapidly into the nest center in a manner similar to a woodpecker hammering on a tree. We (NG and JMG) have also observed this behavior in the wild and suspect that it may represent an effort to alter an uncomfortable bulge in the nest or to drain a wet spot which has developed in the nest. Almost immediately after settling to incubate, the adults reached out and using a raking action with their beaks pulled twigs and straw into a mound surrounding the body. This raking action to build up the nest cup lasted from several seconds to several minutes every time an adult settled onto the eggs.

Nest relief

Both adults took turns incubating the eggs, with the female taking a much larger share of incubation during the day. However, male and female each incubated 2 or 4 nights for which we have observations. Thirty-nine changeovers were seen. During most changeovers (31) an adult continued to incubate until its partner arrived on the nest edge. When the incubating adult stood up and stepped to the nest edge the relieving adult balled its feet and stepped into the nest center, perhaps walking around the nest a bit first, and arranged nest material or poked in the nest cup. After arriving at the nest center, the relieving adult poked gently into the nest cup, grasped a stable nest branch which it used as a pivot, rocked its body from side to side, and settled into the nest. After settling into the incubation posture, the eagle formed the nest cup.

Eight times the eagle on the nest left before its mate arrived on the nest edge. This happened when the incubating adult had been on the nest for longer than 2 hours or when the weather was warm. Sometimes when the incubating adult had been on the nest for a long time, it stood up, turned about, poked into the nest and then assumed the incubating posture again in exactly the same manner as after nest relief. This routine of gently poking into the nest, settling into the nest with side-to-side rocking, and raking nest material toward the body was seen 50 to 55 times in 55.5 hours of observations.

Lying together in the nest

During 3 occasions near sundown, both eagles lay side by side in incubating posture on the nest. Two of these episodes lasted 3 minutes each, and the third lasted 20 minutes. While lying together, the eagles engaged in billing and stroking each other with their beaks.

Feeding

When caretakers brought food to the pen, the female incubated the eggs, and the male called while flying near the nest. The male then perched and continued calling until the caretaker had left the area, then went down to the ground for food. Three times he fed first and went up to the nest; the female then went down to feed. The male carried food up to the nest for the female on two occasions. She then ate it on the nest while he took over incubation.

Discussion

This investigation was not intended as an exhaustive study of Bald Eagles before and during incubation, but rather as a preliminary investigation into this phase of the species' life history. One must be wary of drawing conclusions from the activities of captive birds. Observations in the wild (Herrick 1934, Retfalvi 1965, N. Gerrard and J. M. Ger-

rard unpub. obs.) suggest, however, that many of the behavior patterns in the wild are similar, yet more complicated. Thus wild birds engage in courtship flights, cooperative hunting, and territorial defense, in addition to the behavior patterns described here.

Perching together is an important preincubation activity in wild Bald Eagles (Retfalvi 1965, N. Gerrard and J. M. Gerrard unpub. obs.) just as it was in this study on captive birds. Precopulation and copulation behavior in wild Bald Eagles is also similar to that reported here (N. Gerrard and J. M. Gerrard unpub. obs.). We suspect, however, that the large proportion of incomplete copulation sequences seen in pair II was caused to a considerable degree by the nearly crippled condition of the male. The nature of the female Bald Eagle solicitation display is similar to that seen in large falcons where body position (head bowed, wings slightly apart) and calling are important (Fyfe 1972, Wrege and Cade 1977). As with other raptors, Bald Eagles use distinctive calls during copulation which are not used at other times (Mueller 1970, Fyfe 1972, Wrege and Cade 1977). Bald Eagles appear to be different from Prairie Falcons in that the male initiated the copulation sequence as often as the female whereas in the Prairie Falcon it was almost always the female which initiated the sequence (Fyfe 1972).

Sitting in incubating posture on a nest without eggs, pseudincubation, as observed in this captive pair, also occurs in wild eagles (N. Gerrard J. M. Gerrard unpub. obs.) and has been observed in some African eagles (Brown 1955). Since the status of a breeding area on early nesting surveys is often judged by the presence of an adult in incubating posture (Whitfield et al 1974), the count may be high because some such birds may not have eggs. The relative roles of the male and female in preincubation activities are noteworthy and show that male eagles, as with other raptors (Hamerstrom and Hamerstrom 1972), can and do participate in nest building and in pseudincubation.

Incubation behavior of the captive Bald Eagles was also similar to that which has been observed in the wild. The sequence of poking in the nest, grasping a branch, settling low into the nest rocking from side to side, and then raking nest materials toward the body to form the nest cup, was exactly the same as we (N. G. and J. M. G.) have seen with wild Bald Eagles in Saskatchewan. Others have written abbreviated descriptions of this behavior in Bald Eagles (Herrick 1934, Retfalvi 1965, Golden Eagles (Grier 1973), and Red-tailed Hawks (Hamerstrom and Hamerstrom 1972).

Our observations that the eagles changed position with associated poking in the nest (probably turning the eggs—Herbert and Herbert 1965) approximately once per hour can be compared to time-lapse photographic observations of Enderson et al. 1972, showing that Peregrine Falcons shifted their position an average of every 34 minutes. These findings may conflict with the statement that birds of prey rarely stand and turn their eggs (Brown and Amadon 1968, p. 111). A possible explanation for this discrepancy lies in Brown's (1955) observations that the response of an eagle to a human intruder is to sit tight and low on the nest. More recent observations in the wild have confirmed Brown's and show that eagles which are disturbed by the presence of an observer react by sitting more closely on the eggs and moving the eggs less frequently (J. M. Gerrard, N. Gerrard, D. W. A. Whitfield and W. J. Maher pers. comm.).

The significant correlation between length of time the eggs were left exposed and the wind chill index suggests that Bald Eagles have the ability to adjust the length of time that the eggs are exposed in relation to the cooling power of the air. Huggins in 1941 showed the effects of wind and air temperature to cool eggs in the wild. The present paper provides quantitative evidence that eagles can adjust to the environmental condi-

tions to regulate egg cooling. Such an ability had been suggested earlier for Song Sparrows by Nice (1937). It is probable that this ability is more important to birds nesting in cold climates. In this regard it is interesting to compare the Bald Eagle, which spent only 2% of the time off the eggs, with the Verreaux's eagle in Africa, which was observed to spend 6.6% of the time off the eggs (Rowe 1947). It is hoped that increased understanding of details such as these in the behavior of Bald Eagles and other raptors during the preincubation and incubation periods will aid in the captive propagation of these species and in the management of raptors in the wild.

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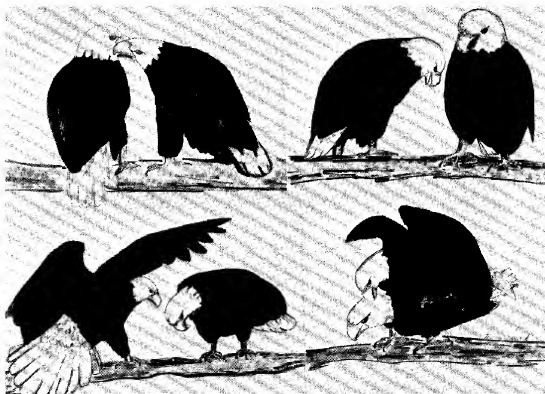


Figure 1.—Copulation behavior in Bald Eagles: a. female approaches male; b. male approaches female; c. male flaps wings and pumps tail while female bows; d. male mounts female.

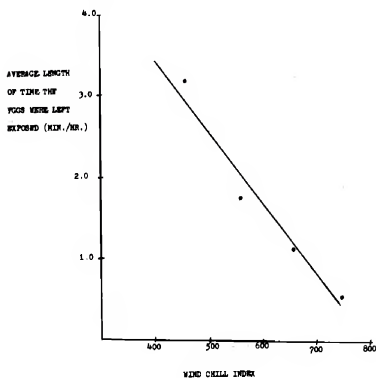


Figure 2.—The time Bald Eagle eggs were left exposed versus wind chill index. Dots represent individual hourly values; squares represent average wind chill index for each 100 unit interval with corresponding average time eggs were left exposed for that 100-unit interval for average values $r = 0.977$; $P < 0.05$).

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